

Compact Multi-Loop Stretcher with OPCPA System

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Background

Today, ultrashort high intensity lasers are used
for the material processing, high field physics, and medical applications and so on

Shorter pulse duration (broader bandwidth)
High contrast
High average power



The OPCPA
has attractive advantages

Broad gain bandwidth ($>100\text{nm}$)
Low thermal loading

Meanwhile, the OPCPA has disadvantages

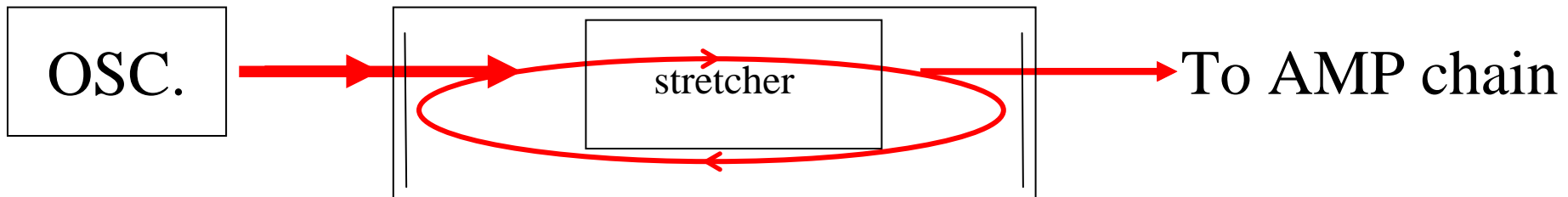
Low efficiency
Complication

:The mismatch of pulse duration between signal and pump pulse.
:For the pulse duration matching, several stretching stages are necessary

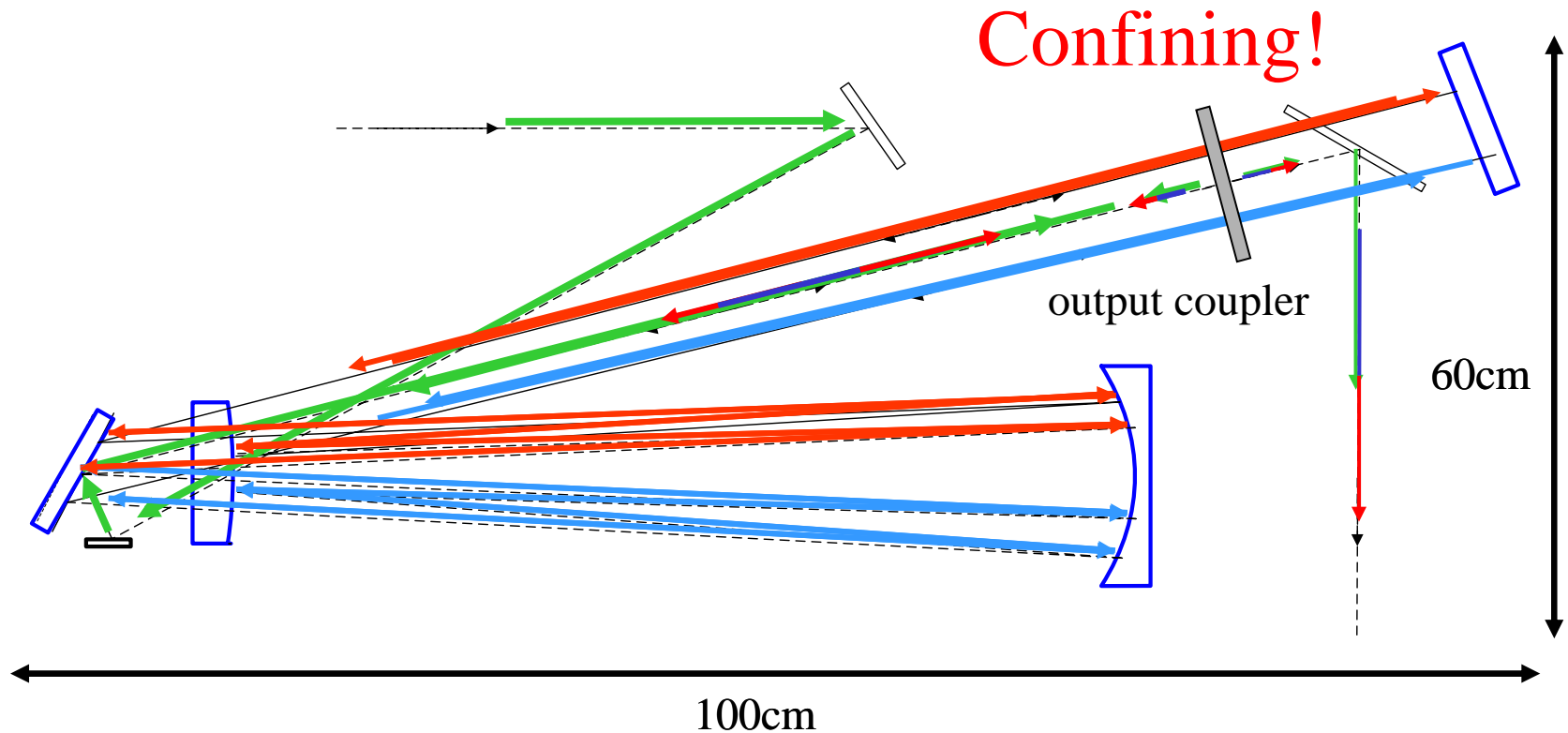
To solve the problem of the pulse duration mismatch

The goal of this study is stretching the short pulse with **100 fs** pulse duration to the **3 ns** pulse duration for supposing the 7ns of the pump pulse duration.

The pulse confining structure

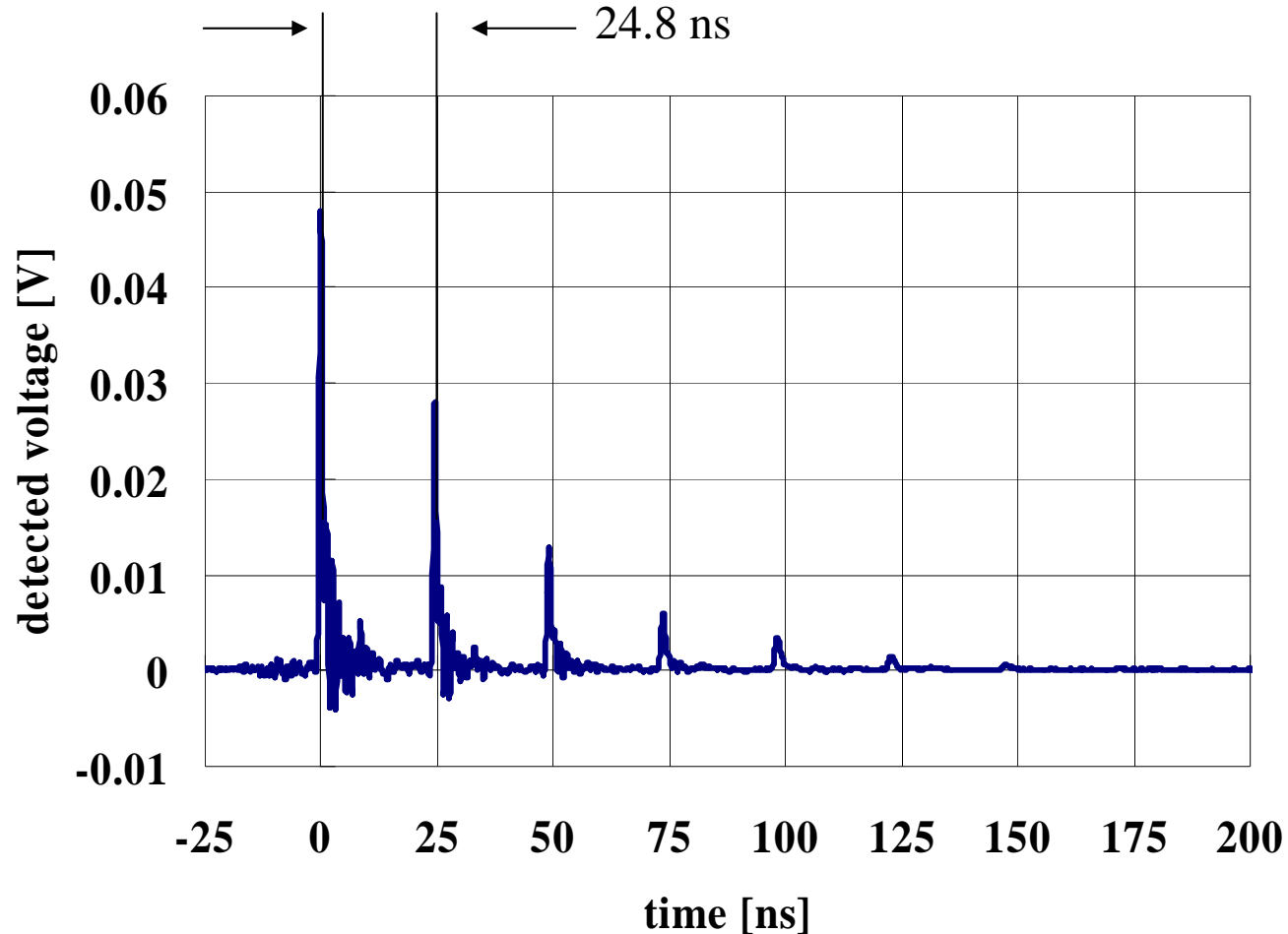


Multi-loop stretcher configuration



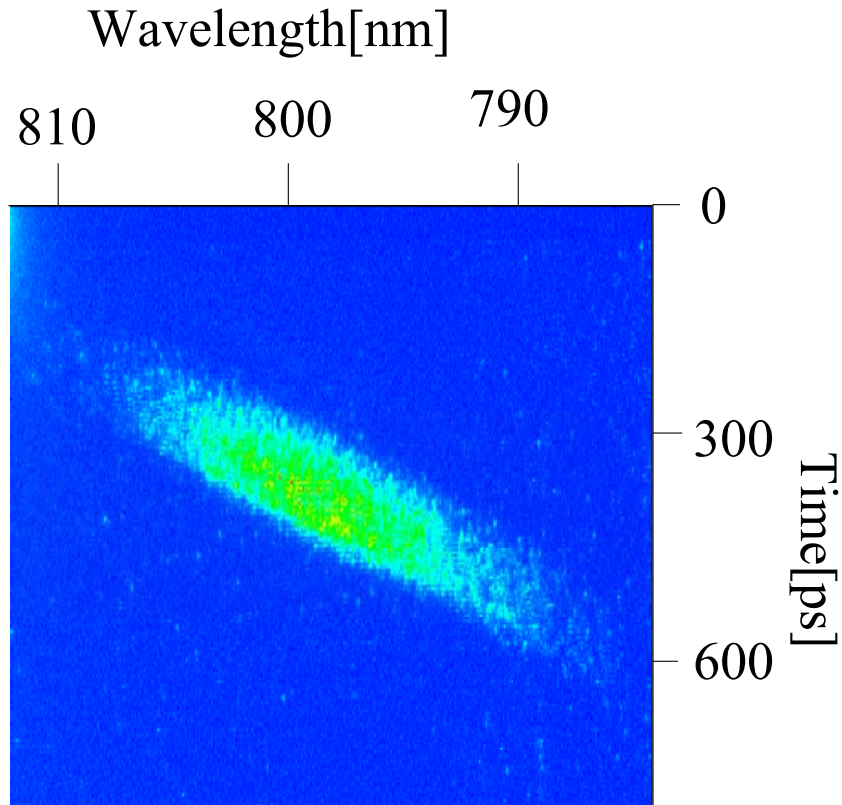
The zero order diffracted beam was injected into the confining structure.
The dielectric mirror was used as a output coupler to confine the pulse.

The output pulse from the stretcher



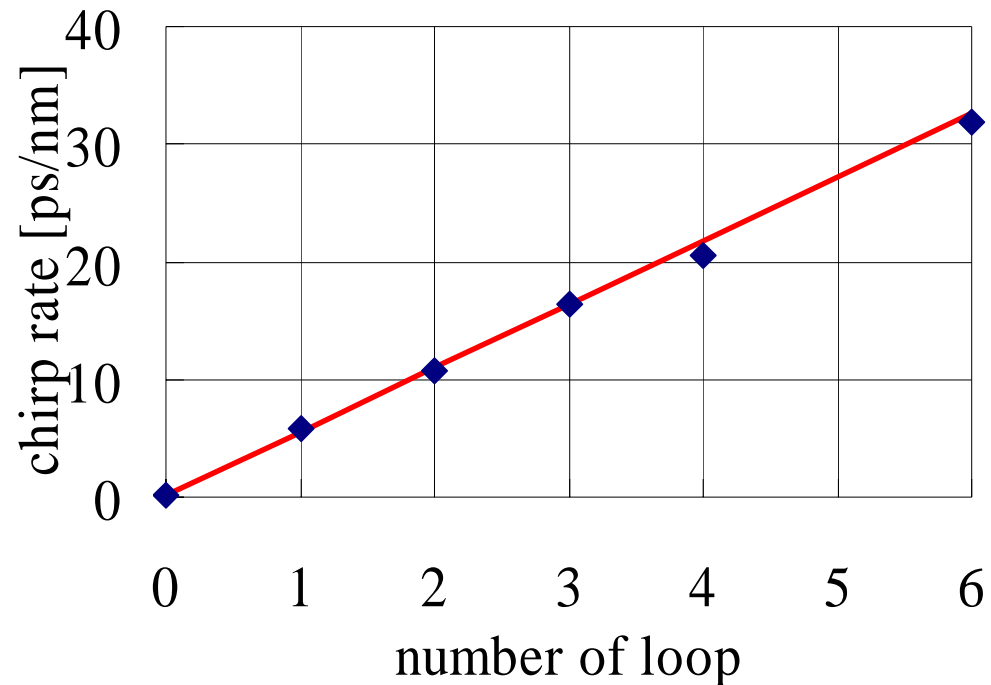
The pulse interval was 24.8 ns, corresponding to the 7.4 m of optical path length of the stretcher.
The pulse energy was decreased to the half with one round trips.

The chirping of pulses



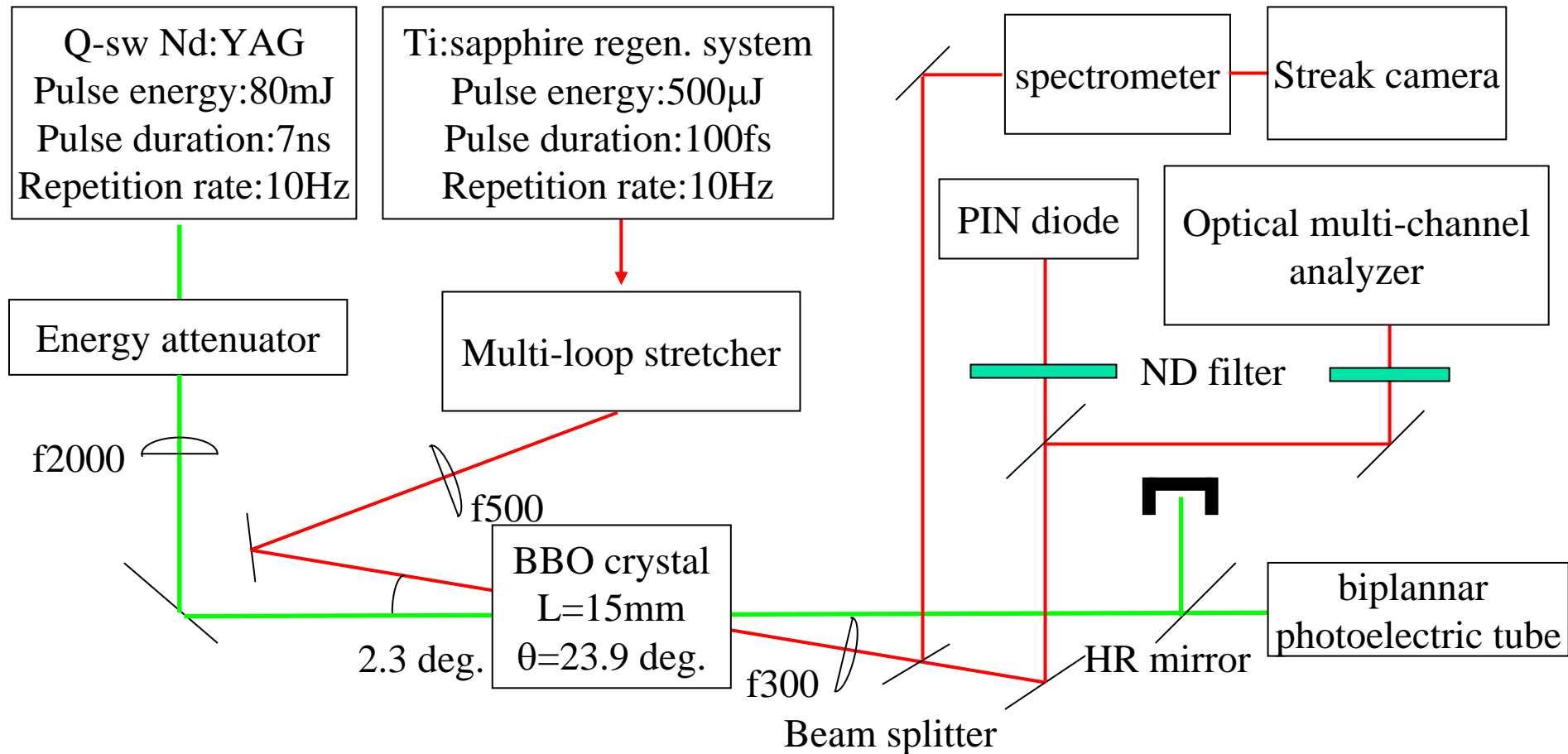
Streak image of the 2 round-tripped pulse

Chirp rate of pulse train



The chirp rate was directly proportional to the number of loop.

Experimental setup

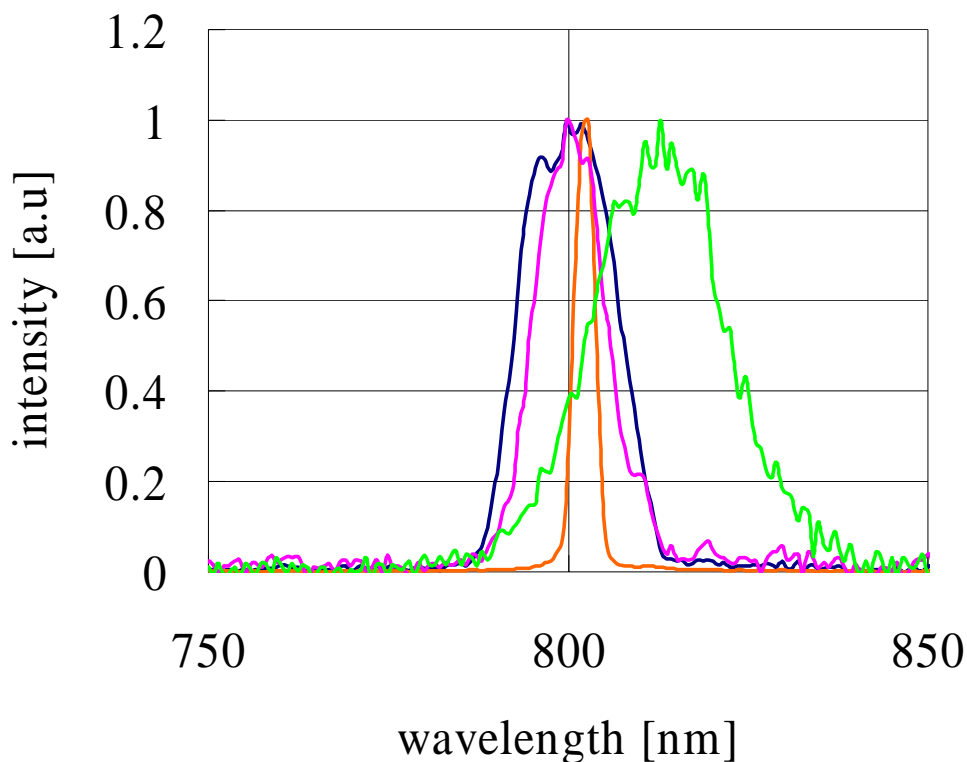


The spectrum of the amplified pulses

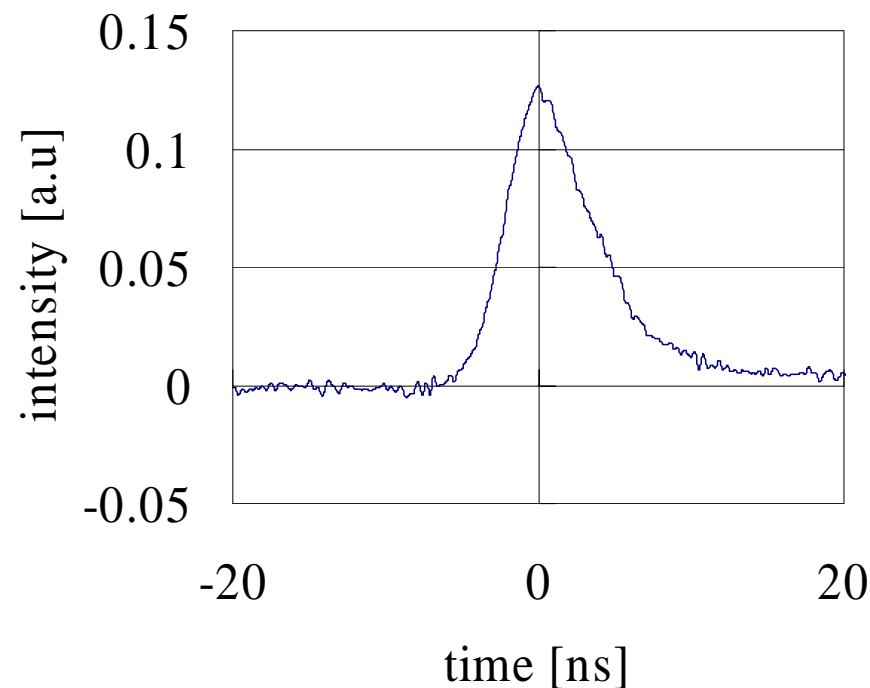


ILE
OSAKA

— 1st-loop — 6th-loop — seed spectrum — OPG

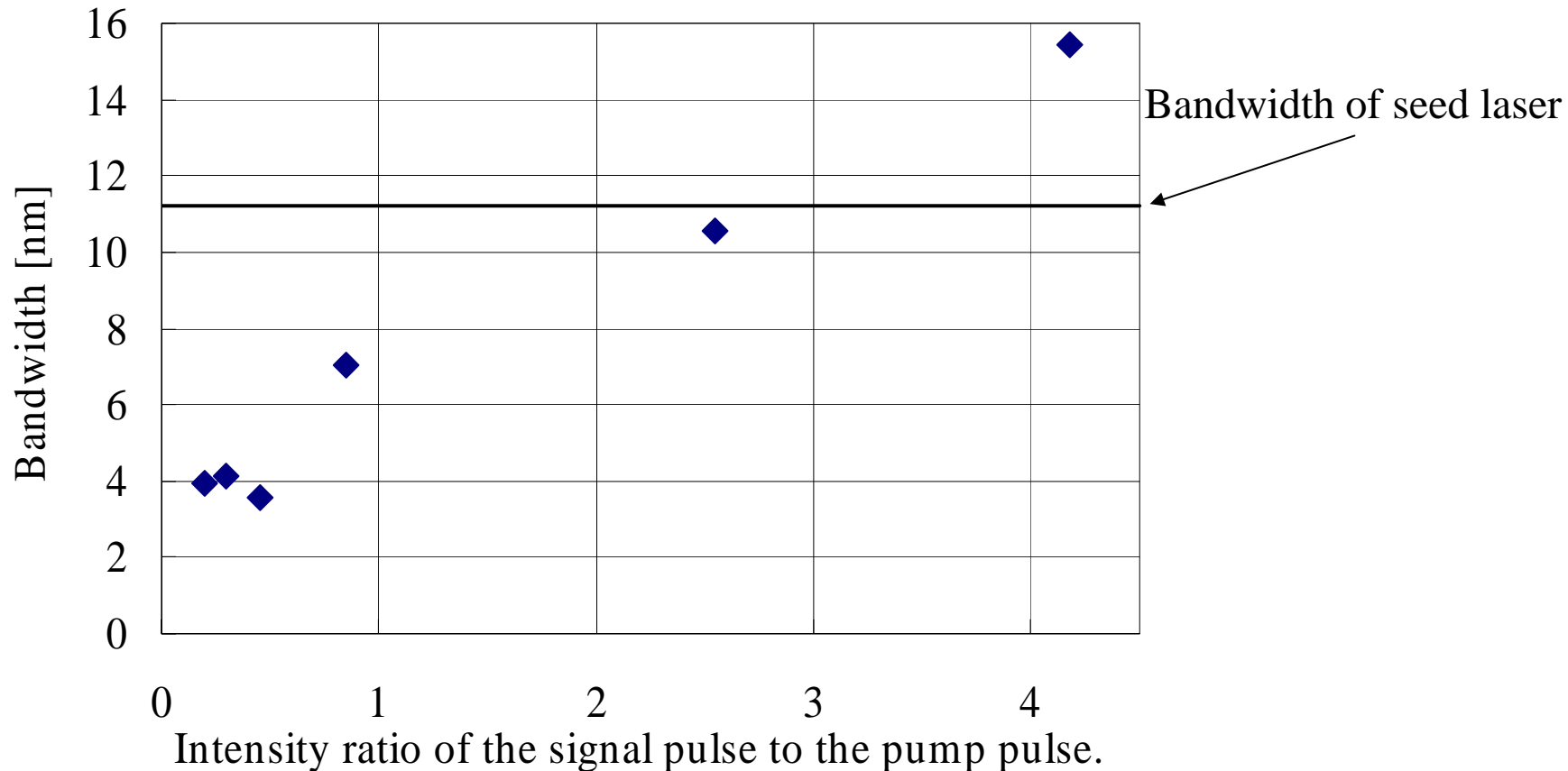


The spectrums of amplified pulses



The temporal pulse shape of the pump laser

Bandwidth broadening and narrowing



Both bandwidth broadening and narrowing are observed.

The amount of these effects depends on the intensity ratio of pump and seed lasers.

Next approach to the 3 ns

Up to this point, 300ps stretched pulse was obtained with 6 round-trips.

The approach to generate the stretched pulse with pulse duration of 3ns

1. Increasing the number of round-trips.

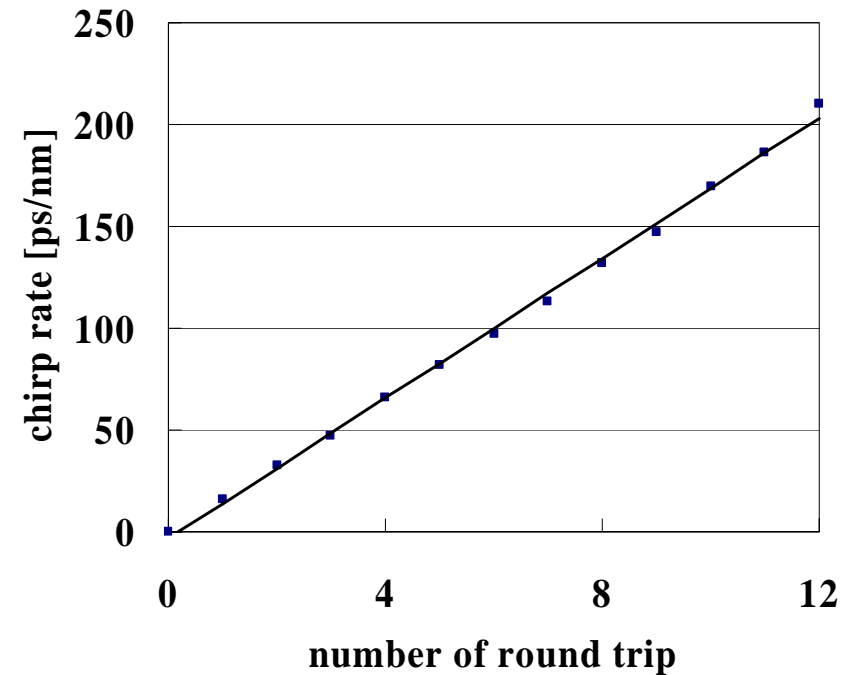
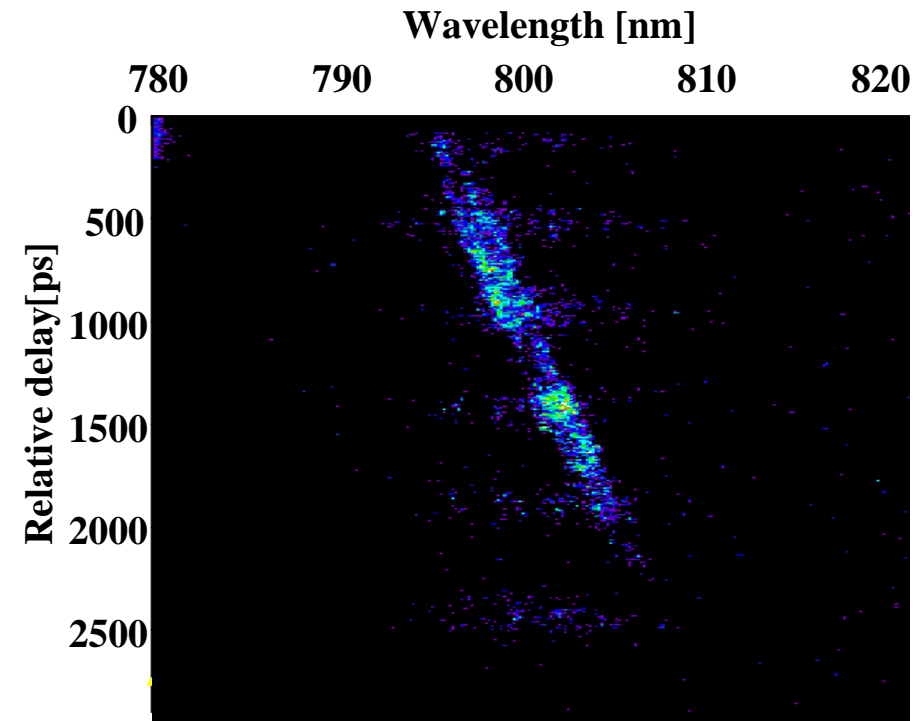
2. Increasing the chirp rate in one round-trips.

Improving the stretcher system for the signal pulse with 10 nm bandwidth



Changed the grating with the groove number of 1800 lines/mm

The chirping of the stretched pulse



The streak image of the chirped pulse

The chirp rates were proportionally increased with the number of round trips.

Summary

We developed the multi-loop stretcher using pulse confining structure.

In there experiments, we demonstrated stretching the 10 nm bandwidth signal pulse up to **2.1 ns** from the small footprint of 1 m by 0.8 m compact stretcher.

In order to compensate the energy loss in the stretcher, we combined the stretcher with OPCPA stage and investigated spectral characteristic of the amplified pulse.

The gain narrowing and gain broadening were observed. The narrowed bandwidth would be compensated by adding another OPCPA stage operating under saturation. The gain broadened (factor of 1.4) 1st-loop pulse showed its possibility.

We think this multi-loop stretcher and OPCPA configuration have a great potential as a front-end system of high average, high peak power laser.